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Jayanth

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(54) **CONTROL AND PROTECTION SYSTEM FOR A VARIABLE CAPACITY COMPRESSOR**

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This patent is subject to a terminal disclaimer.

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F25B 1/00 (2006.01)
H02P 1/54 (2006.01)

(52) **U.S. Cl.** **62/228.5**; 62/228.1; 318/109

(58) **Field of Classification Search** 62/228.5, 62/157, 228.1; 417/44.1, 45
See application file for complete search history.

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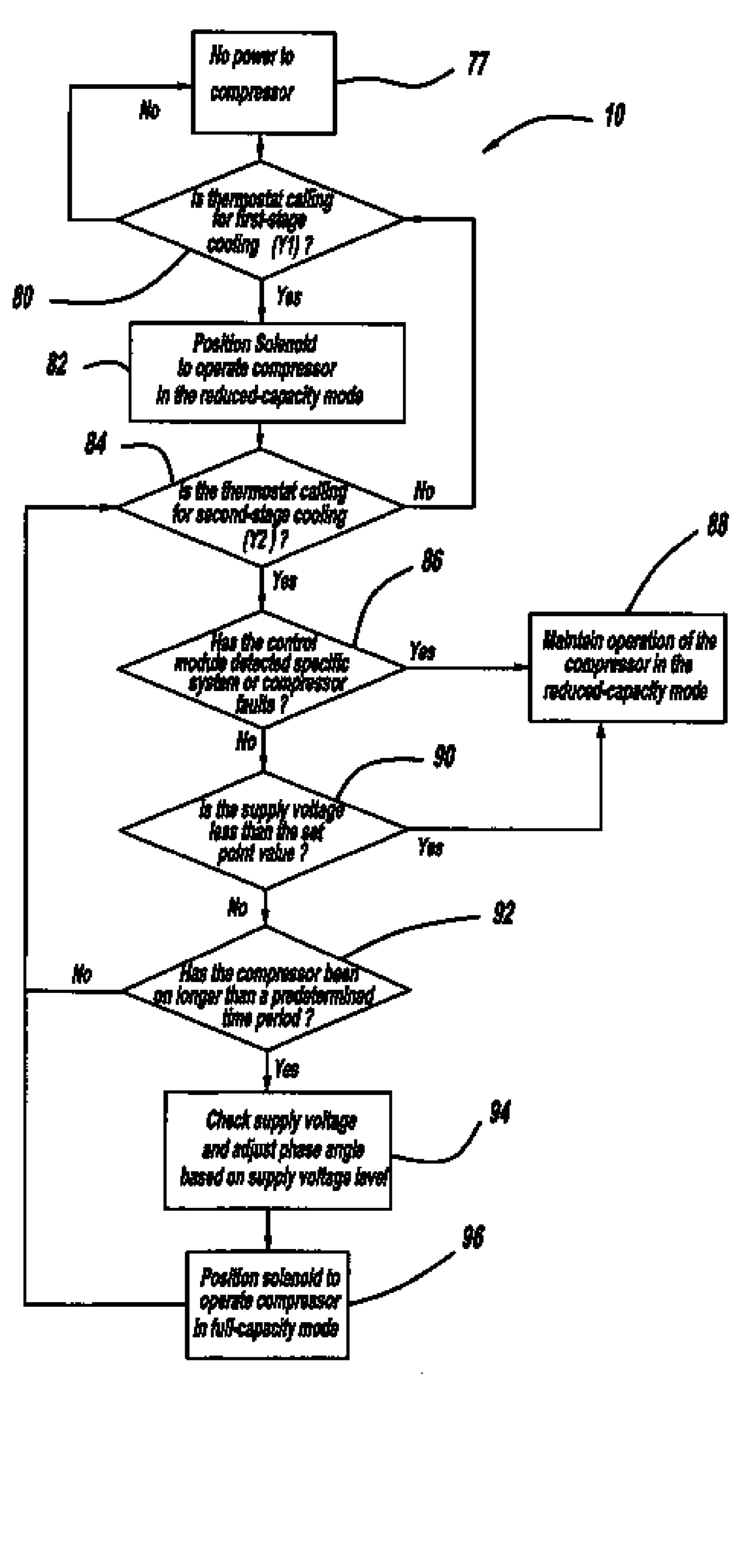
(57) **ABSTRACT**

A system includes a power source, a compressor that operates in a reduced-capacity mode and a full-capacity mode, and an actuation assembly that modulates the compressor between the reduced-capacity mode and the full-capacity mode. A controller reduces the power source to a predetermined level prior to the power source being supplied to the actuation assembly for use by the actuation assembly in controlling the compressor between the reduced-capacity mode and the full-capacity mode.

26 Claims, 6 Drawing Sheets



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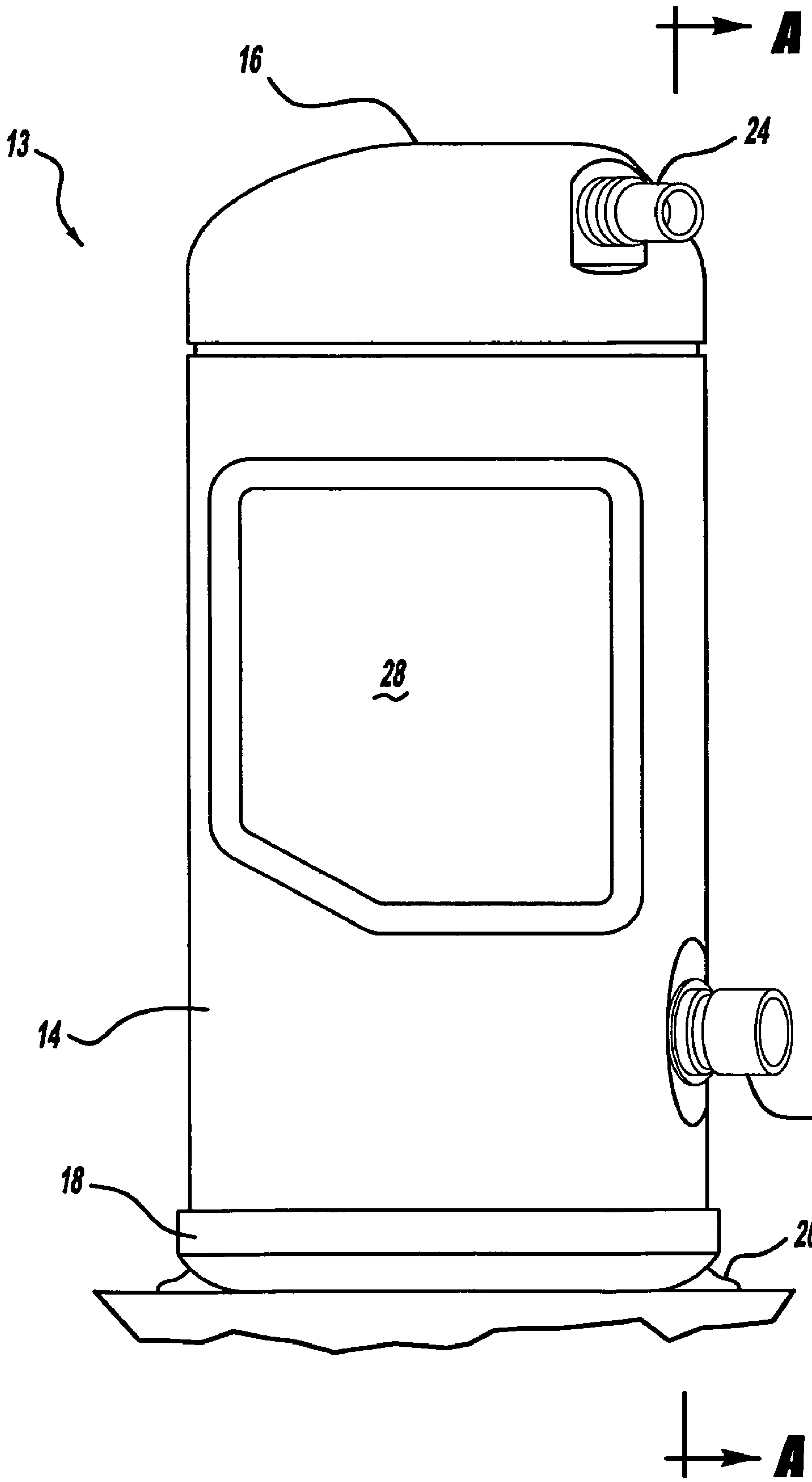
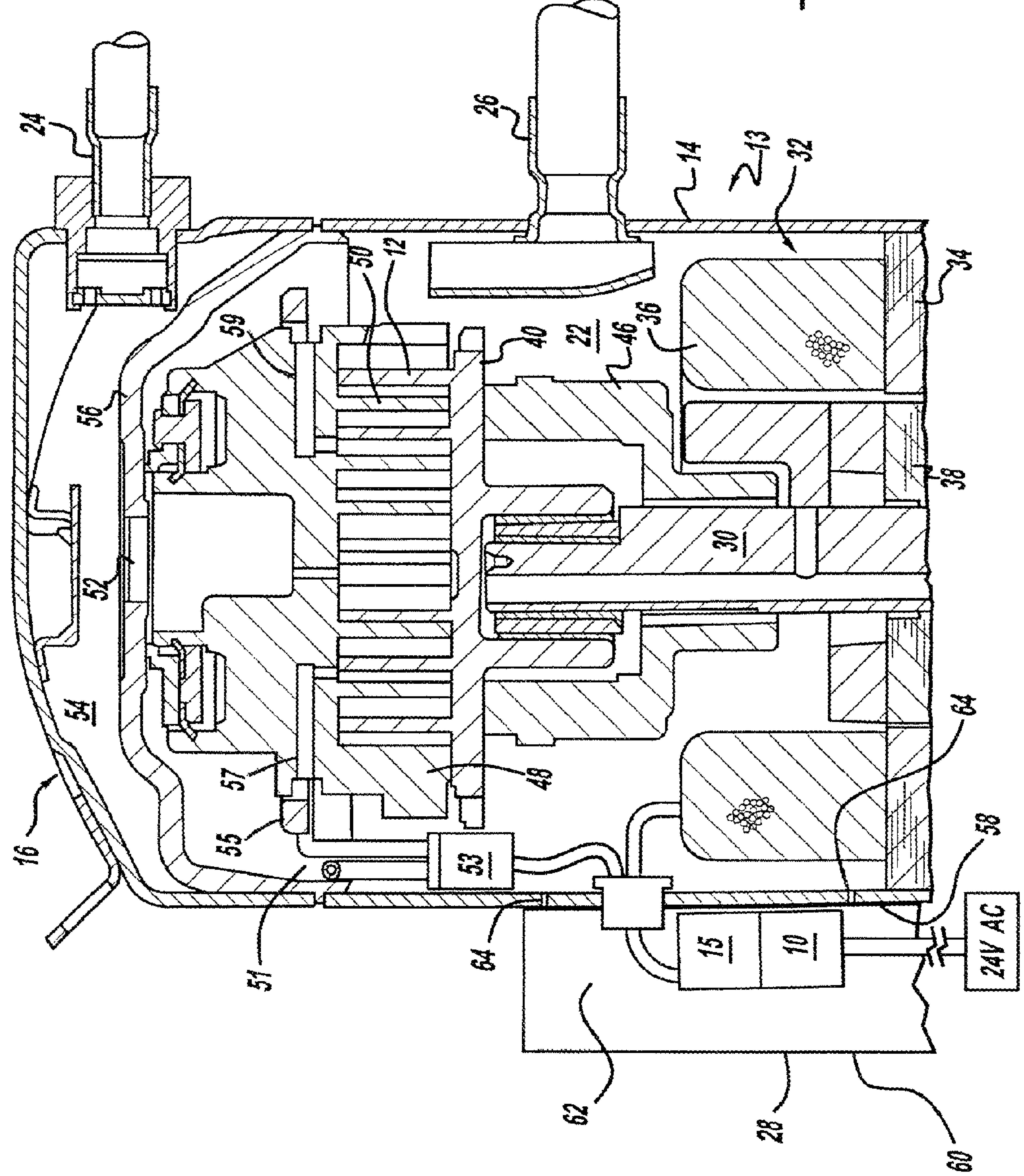


FIG - 1



24
26
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12
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52
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16
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48
53
51
30
38
64
15
10
24V AC
58
64
62
28
60

FIG - 2

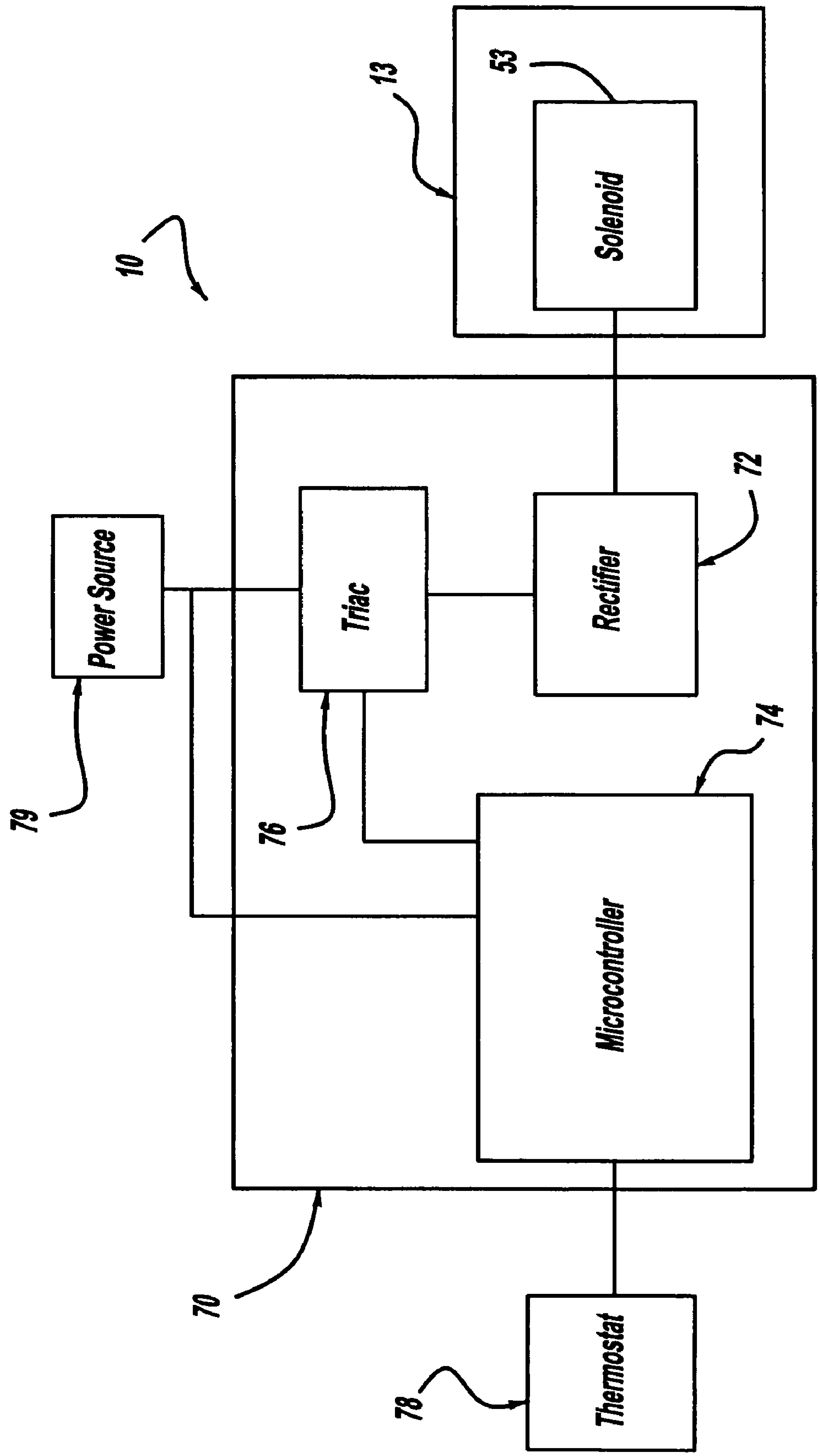
10
13
53
Solenoid
72
Rectifier
Triac
Power Source
79
76
74
Microcontroller
70
Thermostat
78

FIG - 3

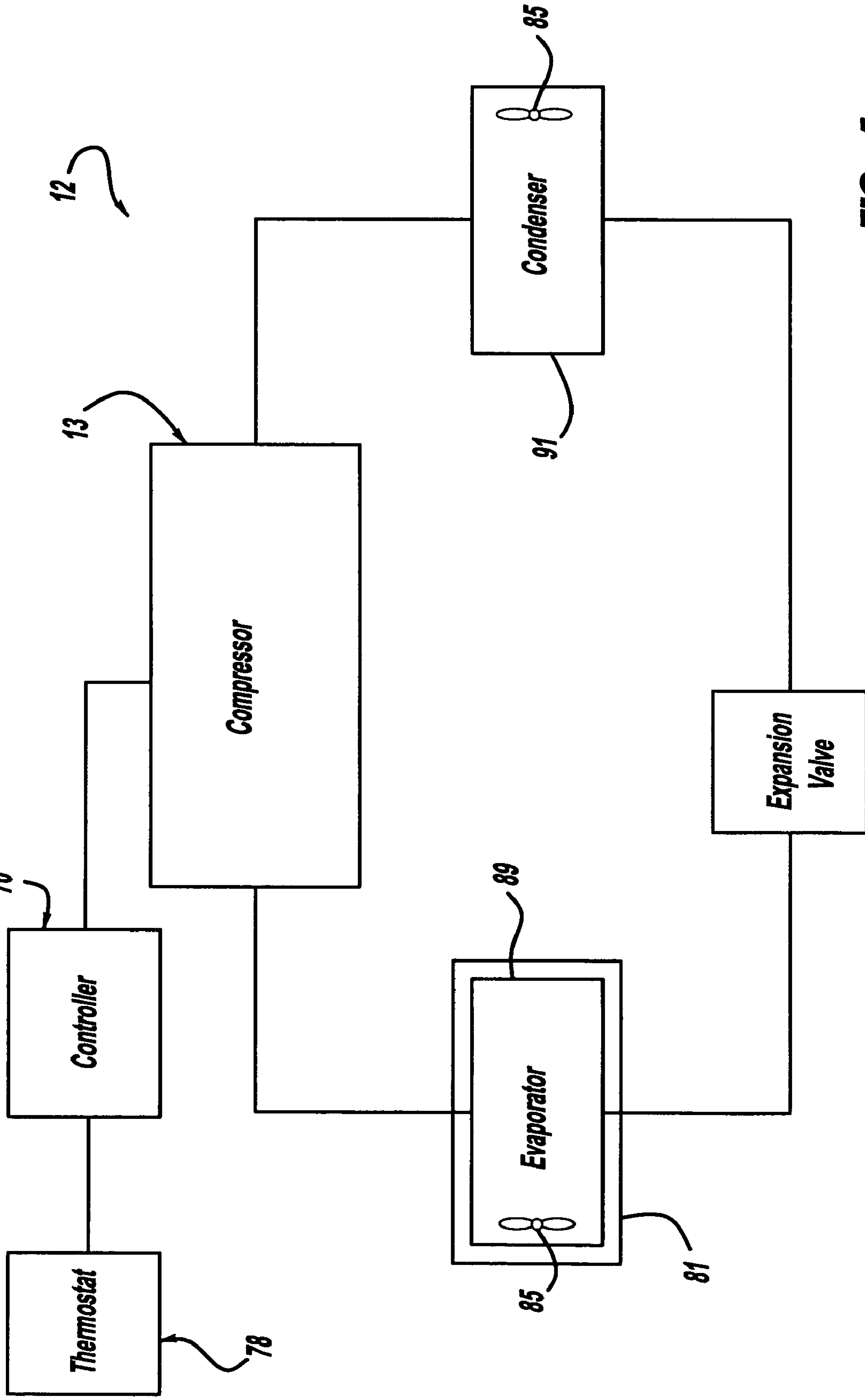
12
85
Condenser
91
13
Compressor
Expansion Valve
70
Controller
89
Evaporator
81
85
Thermostat
78

FIG - 4

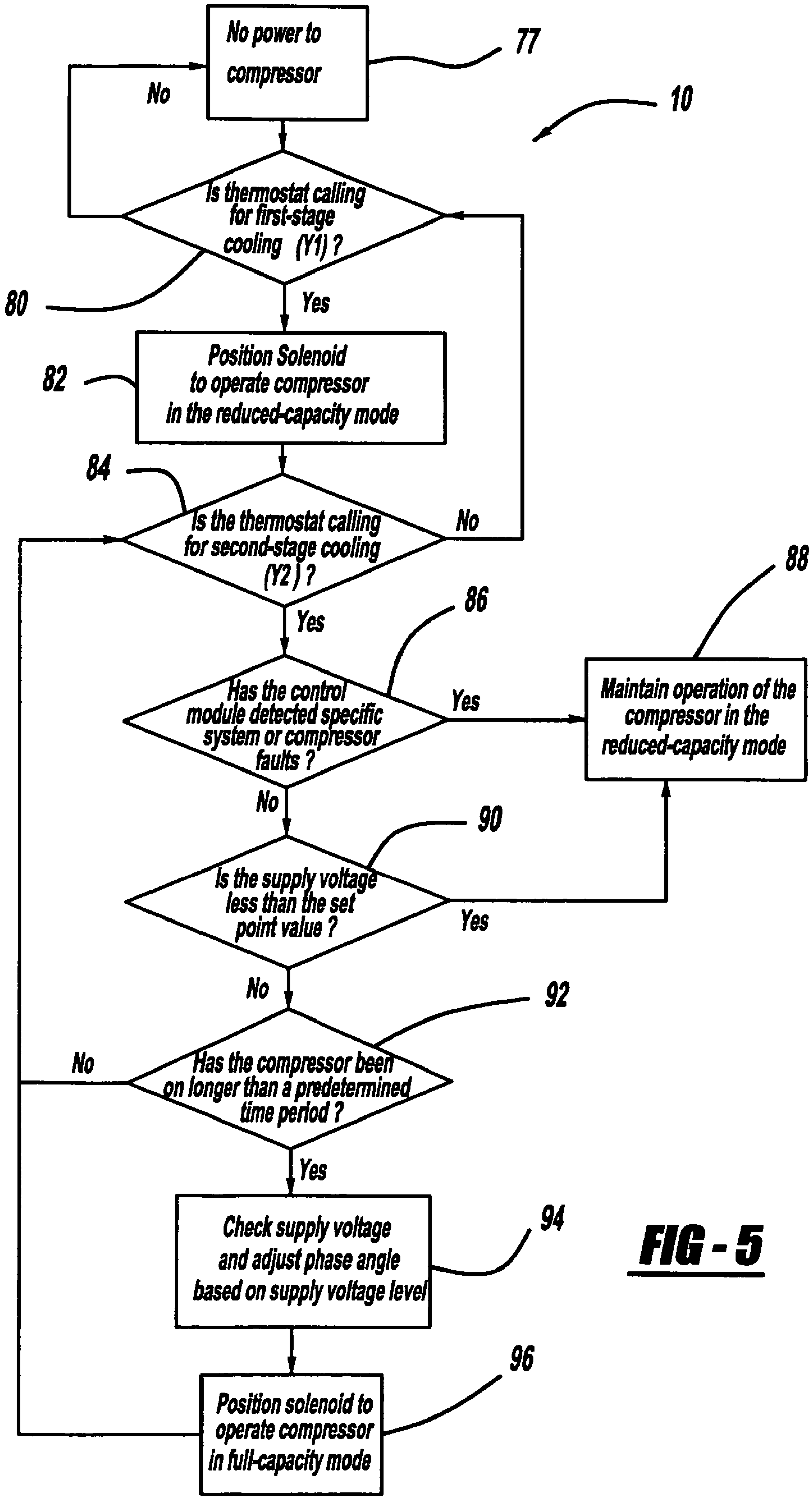
No power to compressor
77
10
No
Is thermostat calling for first-stage cooling (Y1) ?
80
Yes
Position Solenoid to operate compressor in the reduced-capacity mode
82
84
Is the thermostat calling for second-stage cooling (Y2) ?
No
Yes
86
88
Has the control module detected specific system or compressor faults ?
Yes
Maintain operation of the compressor in the reduced-capacity mode
No
90
Is the supply voltage less than the set point value ?
Yes
No
92
No
Has the compressor been on longer than a predetermined time period ?
Yes
Check supply voltage and adjust phase angle based on supply voltage level
94
96
Position solenoid to operate compressor in full-capacity mode

FIG - 5

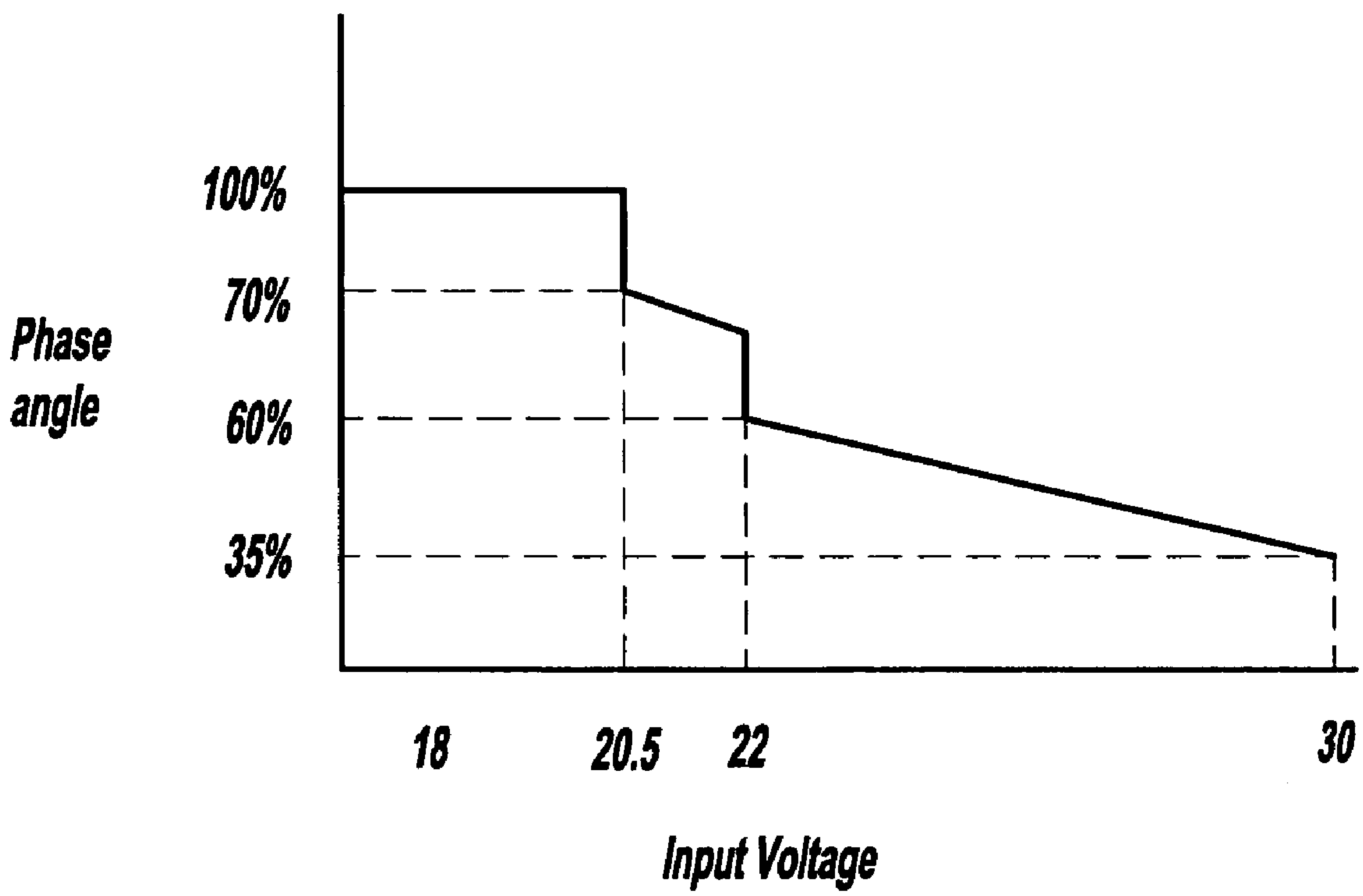

FIG - 6

CONTROL AND PROTECTION SYSTEM FOR A VARIABLE CAPACITY COMPRESSOR

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Application No. 60/684,109, filed on May 24, 2005. The disclosure of the above application is incorporated herein by reference.

FIELD

The present teachings relate to compressors and, more particularly, to a capacity-modulated compressor.

BACKGROUND

Cooling systems such as those used in residential and commercial buildings typically include at least one compressor that circulates refrigerant between an evaporator and a condenser to provide a desired cooling effect. The compressor may be tied either directly or indirectly to a thermostat capable of controlling operation of the compressor and, thus, operation of the cooling system. The thermostat is typically disposed in an area within a residential or commercial building that is centrally located or is otherwise indicative of the temperature within the building.

The compressor associated with the cooling system may output pressurized refrigerant at more than one capacity. Such compressors allow the thermostat to choose between a full-capacity mode and a reduced-capacity mode to more closely match compressor output with the cooling requirements of the building.

An actuation device, such as a solenoid, may be used to modulate compressor capacity between the reduced-capacity mode and full-capacity mode by selectively providing leak paths between a non-orbiting scroll member and an orbiting scroll member of the compressor. The leak paths are achieved by selectively separating the scrolls—radially or axially—to reduce the ability of the scrolls to compress refrigerant.

The solenoid may be selectively supplied with power to toggle the compressor between the reduced-capacity mode and full-capacity mode and typically experiences a rise in temperature due to the supplied power. Furthermore, because the solenoid interacts with at least one of the orbiting scroll member and the non-orbiting scroll member, the solenoid may be partially disposed within a shell of the scroll compressor and additionally experience a rise in temperature due to operation of the compressor. Operation of the solenoid under increased temperature conditions either caused by power supplied to the solenoid and/or lack of refrigerant circulation within the compressor may adversely affect the performance and durability of the solenoid.

Operation of the solenoid under certain operating conditions of the compressor may damage the solenoid and/or compressor. For example, if the compressor experiences a low-side fault, such as a loss of suction pressure, or is simply off, refrigerant is not circulated through the compressor and the solenoid may overheat, if operated. Any other operating condition where the compressor fails to operate (i.e., a locked rotor condition, an electrical fault such as a faulty fan capacitor, an opening winding circuit, etc.) will similarly cause the solenoid to overheat, if operated, and may cause damage to the solenoid and/or compressor.

SUMMARY

A system includes a power source, a compressor that operates in a reduced-capacity mode and a full-capacity mode, and an actuation assembly that modulates the compressor between the reduced-capacity mode and the full-capacity mode. A controller reduces the power source to a predetermined level prior to the power source being supplied to the actuation assembly for use by the actuation assembly in controlling the compressor between the reduced-capacity mode and the full-capacity mode.

Further areas of applicability of the present teachings will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and specific examples, are intended for purposes of illustration only and are not intended to limit the scope of the teachings.

BRIEF DESCRIPTION OF THE DRAWINGS

The present teachings will become more fully understood from the detailed description and the accompanying drawings, wherein:

FIG. **1** is a perspective view of a compressor in accordance with the principles of the present teachings;

FIG. **2** is a cross-sectional view of the compressor of FIG. **1** taken along line A-A;

FIG. **3** is a block diagram of a control system for use with the compressor of FIG. **1**;

FIG. **4** is an environmental view of a cooling system having the compressor of FIG. **1** and the control system of FIG. **3** incorporated therein;

FIG. **5** is a flow chart of the control system of FIG. **3**; and

FIG. **6** is a graph showing phase angle versus input voltage for use with the flow chart of FIG. **5**.

DETAILED DESCRIPTION

The following description is merely exemplary in nature and is in no way intended to limit the teachings, application, or uses.

With reference to the drawings, a control system **10** for a cooling system **12** is provided. The control system **10** monitors operational characteristics of the cooling system **12** and modulates a compressor **13** associated with the cooling system **12** between a reduced-capacity mode and a full-capacity mode. Modulation between the reduced-capacity mode and the full-capacity mode allows the control system **10** to tailor an output of the compressor **13** to the cooling requirements of the system **12** and, thus, increase the overall efficiency of the cooling system **12**.

The compressor **13** may be a variable-capacity compressor and may include a compressor protection and control system (CPCS) **15** that works in conjunction with the control system **10**. The CPCS **15** determines an operating mode for the compressor **13** based on sensed compressor parameters to protect the compressor **13** by limiting operation when conditions are unfavorable. The CPCS **15** may be of the type disclosed in Assignee's commonly owned U.S. patent application Ser. No. 11/059,646, filed on Feb. 16, 2005, the disclosure of which is incorporated herein by reference.

The compressor **13** is described and shown as a two-stage, scroll compressor but it should be understood that any type of variable-capacity compressor may be used with the control system **10**. Furthermore, while the compressor **13** will be described in the context of a cooling system **12**, compressor **13** may similarly be incorporated into other such systems such as, but not limited to, a refrigeration, heat pump, HVAC, or chiller system.

With particular reference to FIG. **1**, the compressor **13** is shown to include a generally cylindrical hermetic shell **14** having a welded cap **16** at a top portion and a base **18** having a plurality of feet **20** welded at a bottom portion. The cap **16** and base **18** are fitted to the shell **14** to define an interior volume **22** of the compressor **13**. The cap **16** is provided with a discharge fitting **24**, while the shell **14** is similarly provided with an inlet fitting **26** disposed generally between the cap **16** and base **18**. In addition, an electrical enclosure **28** is fixedly attached to the shell **14** generally between the cap **16** and base **18** and operably supports a portion of the CPCS **15** therein.

A crankshaft **30** is rotatively driven relative to the shell **14** by an electric motor **32**. The motor **32** includes a stator **34** fixedly supported by the hermetic shell **14**, windings **36** passing therethrough, and a rotor **38** press fitted on the crankshaft **30**. The motor **32** and associated stator **34**, windings **36**, and rotor **38** drive the crankshaft **30** relative to the shell **14** to thereby compress a fluid.

The compressor **13** further includes an orbiting scroll member **40** having a spiral vane or wrap **42** on the upper surface thereof for use in receiving and compressing a fluid. An Oldham coupling **44** is positioned between orbiting scroll member **40** and a bearing housing **46** and is keyed to orbiting scroll member **40** and a non-orbiting scroll member **48**. The Oldham coupling **44** transmits rotational forces from the crankshaft **30** to the orbiting scroll member **40** to thereby compress a fluid disposed between the orbiting scroll member **40** and non-orbiting scroll member **48**. Oldham coupling **44** and its interaction with orbiting scroll member **40** and non-orbiting scroll member **48** may be of the type disclosed in Assignee's commonly owned U.S. Pat. No. 5,320,506, the disclosure of which is incorporated herein by reference.

Non-orbiting scroll member **48** also includes a wrap **50** positioned in meshing engagement with wrap **42** of orbiting scroll member **40**. Non-orbiting scroll member **48** has a centrally disposed discharge passage **52** that communicates with an upwardly open recess **54**. Recess **54** is in fluid communication with discharge fitting **24** defined by cap **16** and partition **56**, such that compressed fluid exits the shell **14** via passage **52**, recess **54**, and fitting **24**. Non-orbiting scroll member **48** is designed to be mounted to bearing housing **46** in a suitable manner such as disclosed in the aforementioned U.S. Pat. No. 4,877,382 or U.S. Pat. No. 5,102,316, the disclosures of which are incorporated herein by reference.

The enclosure **28** includes a lower housing **58**, an upper housing **60**, and a cavity **62**. The lower housing **58** is mounted to the shell **14** using a plurality of studs **64** that are welded or otherwise fixedly attached to the shell **14**. The upper housing **60** is matingly received by the lower housing **58** and defines the cavity **62** therebetween. The cavity **62** may be operable to house respective components of the control system **10** and/or CPCS **15**.

The compressor **13** is shown as a two-stage compressor having an actuating assembly **51** that selectively separates the orbiting scroll member **40** from the non-orbiting scroll member **48** to modulate the capacity of the compressor **13**. The actuating assembly **51** may include a DC solenoid **53** connected to the orbiting scroll member **40** such that movement of the solenoid **53** between a full-capacity position and a reduced-capacity position causes concurrent movement of the orbiting scroll member **40** and, thus, modulation of compressor capacity. While the solenoid **53** is shown in FIG. **2** as disposed entirely within the shell **14** of the compressor **13**, the solenoid **53** may alternatively be positioned outside of the shell **14** of the compressor **13**. It should be understood that while a DC solenoid **53** is disclosed, that an AC solenoid may alternatively be used with the actuating assembly **51** and should be considered within the scope of the present teachings.

When the solenoid **53** is in the reduced-capacity position, the compressor **13** is in a reduced-capacity mode, which produces a fraction of a total available capacity. For example, when the solenoid **53** is in the reduced-capacity position, the compressor **13** may only produce approximately two-thirds of the total available capacity. Other reduced capacities are available, as such as at or below about ten percent to about ninety percent or more. When the solenoid **53** is in the full-capacity position, however, the compressor **13** is in a full-capacity mode and provides a maximum cooling capacity for the cooling system **12** (i.e., about one-hundred percent capacity or more).

Movement of the solenoid **53** into the reduced-capacity position allows a valving ring **55** to move into a position in which passages **57**, **59** are no longer closed off, thereby allowing fluid to be exhausted or vented from moving fluid pockets defined by the intermeshing scroll members **40** and **48** to reduce an output of the compressor **13**. Conversely, movement of the solenoid **53** into the full-capacity position allows movement of the valving ring **55** into a sealing overlying relationship with the passages **57**, **59**, thereby preventing fluid disposed within the moving fluid pockets defined by the intermeshing scroll members **40** and **48** from being exhausted or vented through passages **57**, **59** to increase an output of the compressor **13**. In this manner, the capacity of the compressor **13** may be modulated in accordance with cooling demand or in response to a fault condition. The actuation assembly **51** is preferably of the type disclosed in Assignee's commonly owned U.S. Pat. No. 6,412,293, the disclosure of which is incorporated herein by reference.

With reference to FIGS. **2** and **3**, the control system **10** includes a controller **70** having a rectifier **72**, a microcontroller **74**, and a triac **76** mounted to the shell **14** of the compressor **13** within the enclosure **28**. While the controller **70** is described and shown as being mounted to the shell **14** of the compressor **13**, the controller **70** may alternatively be remotely located from the compressor **13** for controlling operation of the solenoid **53**.

The rectifier **72**, microcontroller **74**, and triac **76** cooperate to control movement of the solenoid **53** and, thus, the capacity of the compressor **13**. The system **10** is supplied by an AC power source **79**, such as 24-volt AC, connected to the triac **76**. The triac **76** receives the AC voltage and reduces the voltage prior to supplying the rectifier **72**. While the triac **76** is described as being connected to a 24-volt AC power source, the triac **76** may be connected to any suitable AC power source.

The microcontroller **74** is connected to the AC power source **79** to monitor the input voltage to the triac **76** and is also connected to the triac **76** for controlling the power supplied to the solenoid **53**. The microcontroller **74** is additionally coupled to a thermostat **78** and controls operation of the triac **76** based on input received from the thermostat **78**. While the controller **70** is described as including a microcontroller **74**, the controller **70** may share a processor such as a microcontroller with the CPCS **15**. Furthermore, while a microcontroller **74** is disclosed, any suitable processor may alternatively be used by both the CPCS **15** and the controller **70**.

The microcontroller **74** may either be a stand-alone processor for use solely by the control system **10** or, alternatively, may be a common processor, shared by both the control system **10** and the CPCS **15**. In either version, the microcontroller **74** is in communication with the CPCS **15**. Communication between the microcontroller **74** and the CPCS **15** allows the microcontroller **74** to protect the solenoid **53** from damage during periods when the CPCS **15** determines a compressor and/or system fault condition.

For example, if the CPCS **15** detects a low-side fault, such as a loss of suction pressure, the microcontroller **74** may react to the particular fault detected and restrict power to the solenoid **53**. Continued operation of the solenoid **53** under a low-side fault, such as a loss of suction pressure, may cause the solenoid **53** to heat up excessively as refrigerant is not cycled through the compressor **13** and therefore does not cool the solenoid **53** during operation. Such action prevents operation of the solenoid **53** when conditions within the compressor **13** and/or system **12** are unfavorable.

The triac **76** is coupled to both the rectifier **72** and the microcontroller **74**. The triac **76** receives AC voltage from the AC power source **79** and selectively supplies reduced AC voltage to the rectifier **72** based on control signals from the microcontroller **74**.

In operation, the rectifier **72** receives the reduced AC voltage from the triac **76** and converts the AC voltage to DC voltage prior to supplying the solenoid **53**. The reduced AC voltage supplied by the triac **76** results in reduced DC voltage being supplied to the solenoid **53** (via rectifier **72**) and therefore reduces the operating temperature of the solenoid **53**. As a result, the solenoid **53** is protected from damage related to overheating. While a triac **76** is disclosed, any suitable device for reducing the AC voltage from the power source **79**, such as, but not limited to, a MOSFET, is anticipated and should be considered within the scope of the present teachings.

With reference to FIGS. **5** and **6**, operation of the control system **10** and cooling system **12** will be described in detail. The solenoid **53** is initially biased into the reduced-capacity position such that the compressor **13** is in the reduced-capacity mode. Positioning the solenoid **53** in such a manner allows the compressor **13** to commence operation in the reduced-capacity mode (i.e., under part load). Initially operating the compressor **13** in the reduced-capacity mode prevents excessive and unnecessary wear on internal components of the compressor **13** and therefore extends the operational life of the compressor **13**. Starting the compressor in the reduced-capacity load also obviates the need for a start capacitor or a start kit (i.e., a capacitor and relay combination, for example) and therefore reduces the cost and complexity of the system.

In operation, the thermostat **78** monitors a temperature of a refrigerated space **81**, such as an interior of a building or refrigerator to compare the detected temperature to a set point temperature (FIG. **4**). The set point temperature is generally input at the thermostat **78** to allow an occupant to adjust the temperature inside the building to a desired setting. When the thermostat **78** determines that the detected temperature in the refrigerated space **81** exceeds the set point temperature, the thermostat **78** first determines the degree by which the detected temperature exceeds the set point temperature.

If the detected temperature exceeds the set point temperature by a minimal amount (e.g., between one and three degrees Fahrenheit), the thermostat **78** calls for first-stage cooling by generating a first control signal (designated by Y**1** in FIG. **5**). If the detected temperature exceeds the set point temperature by a more significant amount (e.g., greater than five degrees Fahrenheit), the thermostat **78** calls for second-stage cooling by generating a second control signal (designated by Y**2** in FIG. **5**). The respective signals Y**1**, Y**2** are sent to the microcontroller **74** of the control system **10** for modulating compressor capacity between the reduced-capacity mode and the full-capacity mode through modulation of the solenoid **53**.

The above operation is based on use of a two-stage thermostat capable of producing multiple control signals based on operating temperatures within a building. Because two-stage thermostats are relatively expensive, control of the compressor **13** between the reduced-capacity mode and the full-capacity mode may be achieved by monitoring a length of time the compressor **13** is operating in the reduced-capacity mode. For example, if the compressor **13** is operating in the reduced-capacity mode for a predetermined amount of time, and the thermostat **78** is still calling for increased cooling, the microcontroller **74** can toggle the compressor **13** into the full-capacity mode. By allowing the microcontroller **74** to regulate operation of the compressor **13** between the reduced-capacity mode and full-capacity mode based on cooling demand indicated by the thermostat **78** and the time interval in which the compressor **13** is operating in the reduced-capacity mode, use of a two-stage thermostat is obviated. For simplicity, operation of the compressor **13** and related CPCS **15** will be described in conjunction with a two-stage thermostat **78**.

At the outset, the compressor **13** is initially at rest such that power is restricted from the motor **32** at operation **77**. The microcontroller **74** monitors the thermostat **78** for signal Y**1**, which is indicative of a demand for first-stage cooling at operation **80**. If the thermostat is not calling for first-stage cooling, the compressor **13** remains at rest. If the thermostat **78** calls for first-stage cooling, the microcontroller **74** energizes the compressor **13** in the reduced-capacity mode (i.e., part load) to circulate refrigerant through the cooling system **12** at operation **82**. At this point, the solenoid **53** is in the reduced-capacity position.

Starting the compressor **13** under part load (i.e., in the reduced-capacity mode) reduces the initial load experienced by the compressor **13**. The reduction in load increases the life of the compressor **13** and promotes starting of the compressor **13**. If the compressor **13** is started in the full-capacity mode (i.e., when the solenoid **53** is in the full-capacity position), the compressor **13** may experience difficulty due to the heavier load

Once operating in the reduced-capacity mode, the microcontroller **74** monitors the thermostat **78** for signal Y**2**, which is indicative of a demand for second-stage cooling at operation **84**. If the thermostat **78** is not calling for second-stage cooling, the microcontroller **74** continues to monitor the thermostat **78** for a Y**2** signal and continues operation of the compressor **13** in the reduced-capacity mode until the thermostat **78** ceases to call for fist-stage cooling. If the thermostat **78** calls for second-stage cooling, the microcontroller **74** determines if the CPCS **15** has detected any specific system or compressor faults at operation **86**. If the CPCS **15** has detected a specific compressor or system fault, the microcontroller **74** maintains operation of the compressor **13** in the reduced-capacity mode at operation **88**, regardless of the demand for second-stage cooling to protect the compressor **13** and solenoid **53** from full-capacity operation under unfavorable conditions.

Compressor faults such as a locked rotor condition, electrical faults such as a faulty fan capacitor or an opening winding circuit, and/or a system fault such as a loss of charge or a dirty condenser, may cause damage to the compressor **13** and/or solenoid **53** if the compressor **13** is operating in the full-capacity mode. Therefore, the microcontroller **74** maintains operation of the compressor **13** in the reduced-capacity mode to protect the compressor **13** and the solenoid **53** when the CPCS **15** detects such a compressor, electrical, and/or system fault.

If the CPCS **15** has not detected a compressor or system fault, the microcontroller **74** then checks the pilot voltage level (i.e., voltage source **79**) supplied to the triac **76** at operation **90**. For an exemplary 24-volt AC power source, if the input voltage is less than approximately 18 volts, the microcontroller **74** maintains the solenoid **53** in the reduced-capacity position, and thus, the compressor **13** in the reduced-capacity mode, regardless of the demand for second-stage cooling at operation **88**. However, if the input voltage is greater than approximately 18 volts, the microcontroller **74** determines if the compressor **13** has been running for a predetermined time period at operation **92**.

If the compressor **13** has been operating for a time period that is less than about five seconds, the microcontroller **74** continues operation of the compressor **13** in the reduced-capacity mode by maintaining the position of the solenoid **53** in the reduced-capacity position. While a time period of about five seconds is disclosed, any suitable time period may be used.

If the microcontroller **74** determines that the compressor **13** has been operating longer than approximately five seconds, the microcontroller **74** once again checks the pilot voltage supplied to the triac **76** and adjusts the phase angle of the supplied AC voltage at operation **94**. The detected voltage is referenced on a phase-control angle graph (FIG. **6**) to determine a suitable phase-angle for use by the triac **76** in supplying DC voltage to the solenoid **53**.

For example, if the detected voltage is 22 volts, the microcontroller **74** adjusts the phase angle to sixty percent. Furthermore, if the detected voltage is 20.5 volts, the microcontroller **74** adjusts the phase angle to seventy percent. Such adjustments allow the microcontroller **74** to continually supply a proper amount of voltage to the solenoid **53** during periods of voltage fluctuation.

Once the phase angle is determined, the microcontroller **74** positions the solenoid **53** to operate the compressor **13** in the full-capacity mode at operation **96**. The microcontroller **74** supplies DC voltage to the solenoid **53** via the triac **76** for approximately 0.9 seconds. Energizing the solenoid **53** moves the solenoid **53** from the reduced-capacity position to the full-capacity position and changes compressor capacity from the reduced-capacity mode to the full-capacity mode. The microcontroller **74** continues operation of the compressor **13** in the full-capacity mode until the thermostat **78** removes the Y2 signal. While the solenoid **53** is energized for about 0.9 seconds, the solenoid **53** may be energized for a shorter or longer time depending on the particular solenoid **53** and compressor **13**.

When the compressor **13** operates in the full-capacity mode, blowers (schematically represented by reference number **85** in FIG. **4**) respectively associated with an evaporator **89** and condenser **91** should increase rotational speed to increase airflow through the respective heat exchanger. The increased rotational speed may be accomplished by using the same five-second time delay used in actuating the compressor **13** from the reduced-capacity mode to the full-capacity mode such that the increased rotational speed coincides with the transition from first-stage cooling to second-stage cooling.

For example, if the blowers **85** are operating for approximately five seconds, each of the blowers **85** may automatically increase rotational speed to a full-speed state. The increased rotational speed of the blowers **85** is therefore automatically configured to occur at approximately the same time the compressor **13** is modulated into the full-capacity mode and is not a result of a command from the thermostat **78**. This configuration reduces the complexity of the control system **10** while still providing a gain in efficiency and operation.

The control system **10** allows for modulation of a compressor between a reduced-capacity mode and a full-capacity mode by selectively supplying DC voltage to the solenoid **53**. The supplied voltage is supplied via a triac **76** and rectifier **72** to reduce the voltage applied to the solenoid **53**. The reduction in voltage allows the solenoid **53** operate at a lower temperature and, thus, protects the solenoid **53** from overheating. Furthermore, the reduced voltage also provides for use of a smaller transformer (such as in a furnace) with which the cooling system **12** may be associated as less voltage is required to actuate the solenoid **53** between the reduced-capacity position and the full-capacity position.

The control system additionally provides for use of a single-stage thermostat or a two-stage thermostat. As noted above, either thermostat will work with the compressor **13** and CPCS **15**, but choosing the single-stage thermostat rather than a two-stage thermostat reduces the overall cost and complexity of the system. The single-stage thermostat **78** provides two-stage functionality by controlling modulation of the compressor **13** from the reduced-capacity mode to the full-capacity mode by timing how long the compressor **13** operates in the reduced-capacity mode rather than supplying two different cooling signals (i.e., one for reduced-capacity and one for full-capacity). Furthermore, the timing principles may also be applied to operation of evaporator and condenser blowers **85** by coordinating an increase in rotational speed with the increase in compressor capacity. Therefore, the control system **10** reduces both the complexity and cost of the control system **10** and cooling system **12**.

The description of the teachings is merely exemplary in nature and, thus, variations are not to be regarded as a departure from the spirit and scope of the teachings.

What is claimed is:

1. A system comprising a controller operable to reduce power from a power source to a reduced-power level supplied to a solenoid operable between a first position modulating a compressor in a reduced-capacity mode and a second position modulating said compressor in a full-capacity mode, said controller monitoring a voltage supplied by said power source and adjusting the phase-angle of said voltage by referencing said voltage on a relationship of phase-angle and voltage.

2. The system of claim **1**, further comprising a DC power source as the power source.

3. The system of claim **1**, further comprising an AC power source as the power source.

4. The system of claim **3**, wherein said controller includes a rectifier operable to convert the power source from said AC power source to a DC power source.

5. The system of claim **1**, further comprising a triac, said controller controlling said triac to reduce said power source to said reduced-power level.

6. The system of claim **1**, further comprising a thermostat in communication with said controller.

7. The system of claim **6**, wherein said thermostat is a single-stage thermostat operable to supply said controller with a signal indicative of a demand for cooling.

8. The system of claim **7**, wherein said controller is operable to control said compressor based on a run time of said compressor in said reduced-capacity mode and said signal from said thermostat.

9. The system of claim **6**, wherein said thermostat is a dual-stage thermostat operable to supply said controller with a signal indicative of a demand for cooling.

10. The system of claim **9**, wherein said signal includes a first signal and a second signal, said dual-stage thermostat is operable to supply said first signal to said controller to indicate demand for said reduced-capacity mode and operable to supply said second signal to said controller to indicate demand for a said full-capacity mode.

11. The system of claim **1**, wherein said controller is operable to control said compressor based on a run time of said compressor in said reduced-capacity mode.

12. The system of claim **1**, wherein said compressor operates in said reduced-capacity mode at start up.

13. The system of claim **1**, wherein said relationship is a graph of phase-angle versus voltage.

14. The system of claim **1**, wherein said voltage is supplied to a triac after the phase-angle of said voltage is adjusted and prior to being supplied to said solenoid.

15. The system of claim **14**, wherein said controller controls said triac based on information received from a thermostat.

16. A system comprising a controller operable to reduce power from a power source to a reduced-power level supplied to an actuation assembly operable between a first position modulating a compressor in a reduced-capacity mode and a second position modulating said compressor in a full-capacity mode, said controller selectively controlling said actuation assembly to maintain operation of said compressor in said reduced-capacity mode if said compressor experiences a predetermined fault condition.

17. The system of claim **16**, wherein said predetermined fault condition includes at least one of a locked rotor condition, a loss of suction pressure, a loss of power to the compressor, a faulty fan capacitor, an opening winding circuit, a loss of charge, and a dirty condenser.

18. The system of claim **16**, wherein said controller is operable to control said compressor based on a run time of said compressor in said reduced-capacity mode.

19. The system of claim **16**, wherein said actuation assembly includes a solenoid operable to modulate said compressor between said reduced-capacity mode and said full-capacity mode.

20. The system of claim **16**, wherein said controller reduces said power based on at least one of a supplied voltage and a phase control angle graph.

21. The system of claim **16**, further comprising a triac, said controller controlling said triac to reduce said power source to said reduced-power level.

22. The system of claim **16**, further comprising a DC power source as the power source.

23. The system of claim **16**, further comprising an AC power source as the power source.

24. The system of claim **23**, wherein said controller includes a rectifier operable to convert said power source from said AC power source to a DC power source.

25. The system of claim **24**, wherein said compressor is modulated into one of said reduced-capacity mode and said full-capacity mode a predetermined time following start up.

26. The system of claim **16**, wherein said compressor operates in said reduced-capacity mode at start up.

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